TO INVESTIGATE THE INTERACTION OF THE VARIABLES IN OXYGEN CUTTING AND THEIR EFFECTS ON THE QUALITY OF CUT

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TO INVESTIGATE THE INTERACTION OF THE VARIABLES IN OXYGEN CUTTING AND THEIR EFFECTS ON THE QUALITY OF CUT

PETRUS TING PIK HUONG

This thesis is submitted as partial fulfillment of the requirement for the degree of Bachelor of Engineering(Hons.) Mechanical Engineering and Manufacturing System from the Faculty of Engineering Universiti Malaysia Sarawak, 2000

This project report attached hereto,entitled " To Investigate The Interaction Of The Variables In Oxygen Cutting And Their Effects On The Quality Of Cut". Prepared and submitted by Petrus Ting Pik Huong as a partial fulfillment of the requirement for the degree of Bachelor of Engineering with Honours in Mechanical Engineering and Manufacturing System is hereby read and approved by:

Dedicated to my father and mother

Dr.Ha How Ung

(Project Supervisor)

27/9/00

Date

Dedicated to my father and mother

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Abstrak

Projek ini melibatkan pemotongan keluli lembut dengan menggunakan api oksigen. Pemotongan oksigen mempunyai penggunaan yang luas, terutamanya dalam membentuk keluli kepada bentuk yang sesuai diggunakan.

Penggunanya sangat luas pada masa sekarang kebanyakkan saiz dan ketebalan bahagian-bahagian logam hanya boleh dibentuk dengan proses pembentukkan logam yang rumit. Namum demikian dengan penemuan pemotongan oksigen, pembentukkan saiz dan ketebalan boleh dibentuk dengan lebih mudah dan ia sesuai untuk proses yang seterusnya iaitu kimpalan dan sambungan mekanikal yang lain. Pemotongan oksigen juga lebih ekonomi dan ia menambahkan pengeluaran industrian.

Matlamat utama projek ini adalah untuk memfokus terhadap dua pembolehubah yang berkaitan dengan pemotongan oksigen bagi keluli lembut seperti berikut:

i) Kelajuan pemotongan.

ii) Tekanan oksigen pemotong.

Namum demikian, segala maklumat yang berkaitan dengan kedua-dua pembolehubah terdapat dalam pelbagai rujukan khsusnya buku-buku kimpalan contohnya pemotongan oksiasetilena. Laporan terperinci bagi projek ini dibincangkan secara relatif terhadap rujukan-rujukan lain.

Abstract

This project involved cutting of mild steel using oxygen flame. Oxygen cutting being reliable in many ways and caused profound change in industrial practices having to do with the shaping of steel, i.e in its general application.

Its use is now widespread. Many parts in a wide range of sizes and thickness can only be done with difficulty by other metal-shaping processes. Since the cut products are generally used in the 'as cut' condition, and the process is completely adaptable to welding and mechanical joining operations of all types, oxygen has resulted in more economical construction and greatly increased production.

The main purpose of this project is to focus on the two variables necessary for high-quality cutting of mild steel. They are:

i) Travel speed of the cutting torch.

ii) Cutting oxygen pressure.

Since the information and the data concerning the two variables are available in many books, especially books on welding, i.e under gas cutting, this report might also be of relevance for comparison. The detail of the project is discussed in this report.

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List of abbreviations

m.s - mild steel

HRB - Rockwell hardness scale B, hardness value introduced by the ASTM

ASTM - American Society Testing And Materials.

HAZ - Heat Affected Zone

p.s.i - pound per square inch

kgf - Kilogram Force

Chapter 1

Introduction and Objective

1.1 Background

Oxygen cutting is the most commonly used process for cutting thick structural steel, but the process has certain limitations and is generally restricted to ferrous materials.

The oxygen cutting equipment is a portable tool that can be taken to the site or work easily. It has been used to cut a wide range of thicknesses. It provides a rapid means of cutting not only straight but many different shapes to the required dimensions.

The use of oxygen cutting which is also known as oxy-fuel gas cutting (OFC) has begun in the early of the 20^{th} century. There are a number of fuel gases used and the most popular one is acetylene. Natural gas such as propane, methylacetylene-propadience stabilized and various trade named fuel gasses are also widely used. Hydrogen is rarely used because of its highly explosive nature.

Each fuel gas has its particular characteristic. The characteristics relate to the flame temperatures, heat content, oxygen fuel gas ratio and so on.

The general concept of oxyfuel gas cutting is similar no matter what fuel gas is used. It is the oxygen jet that makes the cut in steel, and cutting speed depends on how efficiently the oxygen reacts with the steel.

The project is designed to study the interaction of the variables in each process and their effects on the quality of cut.

1.2 Objectives

The Objectives of this project are as follows:

1) To investigate the effect of cutting speed on the quality of cut in different thicknesses of mild steel.
2) To investigate the effect of cutting oxygn pressure on the quality of cut in different thicknesses of mild steel.
3) To establish best parameters for a good quality cut for various thickness.

Chapter 2

Literature Review

2.1 Definition of oxygen cutting

Oxygen cutting is defined as a group of cutting processes where in the severing or removing of metals is effected by means of the chemical reaction of oxygen with the base metal at elevated temperatures. In the case of the oxidation-resistant metals the reaction is facilitated by the use of a chemical flux or metal powder. This flux may be in the form of a metallic or chemical powder or a mixture of both.

2.2 Classification of oxygen cutting process

2.2.1 Machine cutting

In machine cutting, a different type of torch is being used which, in combination with the mechanical parts of the machine that hold it, permits easy adjustment of the nozzle or tip with respect to the work. Where the material to be cut is irregular or wavy along the top surface, the torch may be equipped with a device that automatically

maintains the correct nozzle or tip height above the work. This device may employ a sensing and actuating device which is mechanical, electrical or pneumatic.

According to J.W Giachino [1] the machines, whether of the small tractor or tricycle type or the more elaborated shape cutting variety, are designed so that, regardless of the path being traversed, the cutting speed will remain constant at a preset value. The maintenance of a fixed nozzle height and speed, together with the proper nozzle size and recommended preheat gas and cutting oxygen flow, results in the production of a high-quality surface with good dimensional qualities. A tractor type machine is used for a long straight cuts or circle cuts. Shape cutting is done with a more elaborate machine which follow some type of template or responds to signals from such devices as a numerical tape control. Other machine cutting operations include the nicking of plate edges for welding, and stack cutting.

2.2.2 High-quality cutting

Essentials of a high-quality cut surfaces are: squareness of the top edge, smoothness of cut surface, squareness of the face with regards to top and bottom surface (on a horizontal member), absence of tenacious slag adhering to the surface farthest from the torch, and production of a drop cut. These characteristics are desired on plates where edges are being prepared for welding, for "as cut" fabrication or for good dimensional features. High- quality cuts can be obtained with either cylindrical or divergent bore nozzle. However, attention must be paid to the nozzle selection, cutting oxygen pressure and flow, cutting speed and the quality and type of preheat flame. Light drag lines on cut surfaces are not inherent, and are not considered detrimental to quality.

2.2.3 Drag

When the speed of which the nozzle travels across the work is such that the oxygen stream enters the top of the kerf and exits from the bottom of the kerf along the axis of the nozzle, the cut will have zero drag and be considered a drop cut. If the speed of cutting is increased or if the quantity of cutting oxygen is below the recommended value, the portion of the oxygen jet farthest from the cutting nozzle will not have sufficient energy to carry the products of the reaction straight through the work. The most distant part of the cutting stream will lag behind the portion nearest to the nozzle. The amount of this lag, measured along the line of cut, is refereed to as the drag.

2.2.4 Kerf

The kerf is defined as the gap created by the removal of material by cutting jet as it progresses across the material being cut. Kerf width is important for a number of reasons. Whatever material is removed in the kerf is lost. Control or governing of kerf width plays an important part in the accuracy with which material can be cut to specified dimensions. Maintenance of a uniform kerf width from the torch side to the far side of the cut will govern the squareness of the cut edge. Kerf width is a function of the nozzle size, speed of cutting, quantity and pressure of gas at the nozzle and type of nozzle used. As the thickness of the material being cut increases, it is necessary to use a greater oxygen flows and nozzles or tips with larger cutting oxygen passages in order to obtain a sufficient quantity of oxygen to cut through the material. The width of the kerf will therefore increase as the thickness of the material being cut increases.

Cutting at speeds below those recommended for best quality cuts will usually result in irregularities in the kerf width as the oxygen stream will melt, wash away and oxidise additional quantities of material on each side of the cut. The kerf width is especially important when shape cutting is concerned. In lying out work or when designing templates, compensations must be made for the kerf.

2.2.5 Preheating

Preheating time refers to the time required to heat the base metal to ignition temperature; that is, to a temperature high enough that when the oxygen jet is directed onto the heated area, rapid oxidation will be initiated and the cutting operation can begin.

2.3 Principles of operation

Oxygen cutting is a means by which ferrous metals is severed by a chemical reaction between the iron or its alloys and a confined high purity oxygen (approx. 99.5%) stream. A small area of the metal is preheated to the oxygen ignition temperature (the temperature at which the material will ignite when subjected to an atmosphere of high purity oxygen) of the ferrous metal, and a stream of oxygen is impinged on the heated area. The oxygen rapidly oxidizes the metal in a narrow section, which becomes the kerf as the molten oxide and metal are removed by the kinetic energy of the oxygen stream.

The oxygen cutting process employs a torch and a tip or nozzle whose functions are:-

1. To mix the fuel gas and preheat oxygen in he right proportion to produce the initial heating and continuous heating effect
2. To supply a stream of high-purity oxygen at the reaction zone for the purpose of oxidizing and removing the molten materials.

The torch unit is then conveyed across the material to be cut. At a speed sufficient to produce a continuous cutting action. This motion may be accomplished either manually or mechanically. The manual method depends very much on the skill of the individual, while the machine method produces more accurate results with superior finish.

2.4 Chemistry of oxygen cutting

The process of oxygen cutting is based on the capacity of high purity oxygen to combine rapidly with iron that has been heated to the kindling temperature. Thus, when iron or steel is heated to its oxygen ignition temperature and brought into contact with high purity oxygen, the iron is rapidly oxidized.

The reaction can be represented by the following equations:

$Fe + O$ $FeO + Heat$.....First reaction

$3Fe + 2O_2$ $Fe_3O_4 + Heat$.....Second reaction

$2Fe + 3/2O_2$ $Fe_2O_4 + Heat$.....Final reaction

From the past analysis, not all the iron is completely oxidized to Fe_3O_4. Some unoxidised or only partially oxidized metal is removed by the kinetic energy of the

rapidly moving oxygen stream. The analysis of the slag has shown in some instances over 30% to be iron which has not been oxidized.

2.5 Oxygen cutting techniques

In Oxygen cutting, the preheating gases are first lighted, either with a spark lighter or pilot light, and the pressures adjusted so that the flames are stable, with or without the cutting oxygen flowing. Individual valves are generally so arranged that they are independent of the controls for the preheating fuel gas, the oxygen for preheating and the oxygen used for cutting. The preheating flames (neutral flame) are then directed toward the spot where the cut is to be started and are allowed to play upon this area until the glow of the spot indicates that the metal is at its kindling or ignition temperature. The cutting oxygen valve is then opened, and with the preheat flames still burning the torch is advanced at a steady rate along the line of the cut.

In many cases, the nozzle is held perpendicular to the workpiece at a uniform distance above the surface is employed. In some circumstances, the nozzle may be held at angle to the workpiece to obtain a slanting (cut) edge.

2.6 Effect of oxygen purity

Oxygen used for cutting operations should operations should have a purity of 99.5% reduces the efficiency of the cutting operation. A 1 % decrease in oxygen purity will result in approximately a 25% decrease in cutting speed, with a resulting increase of about 25% in the cutting oxygen consumption. The quality of the cut will be impaired and the amount and tenacity of the adhering slag will increase. At oxygen purifies below 95%, the familiar cutting action disappears and is replaced by a melt and wash action which is usually not acceptable for commercial operations. It is known that these changes are due to the chemical nature of oxygen cutting although the precise rations of cutting oxygen purity and cutting speeds, for example, have not been agreed upon.

2.7 Effects of the cutting process.

2.7.1 Metallurgical changes

As explained earlier, a large quantity of heat is liberated in the kerf when steel is cut with oxygen jet. Much of this heat is transferred to the sides of the kerf, thereby heating the adjacent to the kerf to a temperature above the critical temperature of steel. Since the torch is moving forward constantly at preset value, the source of heat quickly moves on and the mass of cold metal near the kerf acts as a quenching medium (besides being cooled by air i.e normalising) and rapidly cools the heated metal. The steel will harden to a degree which depends on the amount of carbon and alloying elements present (in the case of alloyed steel), as well as the thickness of the material being cut..